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EXTENDED AERATION SEWAGE TREATMENT ON U. S. CORPS OF ENGINEERS DREDGES

Federal Water Pollution Control
Administration
Cincinnati, Ohio

January 1969

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EXTENDED AERATION SEWAGE TREATMENT ON U.S. CORPS OF ENGINEERS DREDGES

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Field Investigations Branch
Division of Technical Support

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ACKNOWLEDGEMENT

Throughout the study, extensive help and cooperation was provided by the Masters and Chief Engineers on each of the dredges involved; personnel in the Office Chief of Engineers; District and Area offices of the Corps of Engineers; Marine Division, North Atlantic Division, New York, New York; and the Marine Design Division, Corps of Engineers, Philadelphia, Pennsylvania.

Personnel of the Field Investigations Branch (Formerly Technical Advisory and Investigations Branch), Federal Water Pollution Control Administration, Cincinnati, Ohio, provided the laboratory analyses, sampling and technical consultation. Cooperation was received from the Middle Atlantic and South Central Regional Offices and Headquarters, Federal Water Pollution Control Administration, and the states of North Carolina, Florida and Alabama.

SUMMARY AND CONCLUSIONS

At the request of the Corps of Engineers, a study was conducted to evaluate the extended aeration sewage treatment plants on three Corps-owned dredges.

1. Based on 24-hour composite samples, the biochemical oxygen demand (BOD) and the total suspended solids (TSS) in the effluents varied from 37 to 780 mg/l and 140 to 700 mg/l, respectively.
2. Based on 24-hour composite samples, there were periods when the BOD and TSS in the effluent were greater than in the influent. At other times the BOD and TSS of the effluent were 0.5 and 10 percent respectively, of that in the influent.
3. Chlorination facilities did not operate continually and effectively. The chlorine residual in the effluent varied from 0.0 to 5.0 mg/l.
4. Fecal coliform densities over 1,000,000 MPN/100 ml were frequently observed. These high values indicate inadequate chlorination.
5. Peak rates of flow were 3 to 5 times the average. The average wastewater discharge was 50 gallons per capita per day.

6. Galley wastes had average BOD and TSS of 1620 mg/l and 760 mg/l, respectively; laundry wastes had average BOD and TSS of 270 mg/l and 240 mg/l, respectively.
7. Oxygen demand index, relative stability, volume of floc, and light penetration determinations were evaluated as sewage treatment plant operating control tests.

From this study, it was concluded that:

1. The performance of the sewage treatment plants and the quality of their effluents were erratic. Overloading and/or improper operation are indicated.
2. The chlorination was ineffective because of equipment malfunctions and/or improper operation.
3. Observations indicate several deficiencies in plant design and operation; retention of floating material in the aeration and/or settling tanks was inadequate; air diffusers could not be removed for inspection or replacement without draining the aeration tank; and the discharge of grease to the sewage treatment plants has caused plugged pipelines and has caused floating material to collect on the water surface in the settling tanks.

4. Proper treatment was not afforded peak waste flows and loads. Peak flows and loads were not considered adequately in the treatment plant design.
5. The liquid waste from the galley, dishwasher, laundry, and shower are high in BOD and TSS and waste loads from these sources may equal loads from toilet wastes. These wastes are, in some cases, discharged overboard without treatment.
6. The volume of floc, light penetration and chlorine residual determinations were found to be acceptable sewage treatment plant operating control tests.
7. Treatment from the modified heated sewage treatment plant seemed to be as effective as from an unmodified plant, with a resulting reduction in size and weight of the modified plant.

RECOMMENDATIONS

REGULATIONS

The U. S. Corps of Engineers should give the Federal Water Pollution Control Administration an opportunity to review and recommend changes to any regulations pertaining to sewage, sewage treatment, wastewaters or other liquid wastes.

MODIFICATIONS

It is recommended that modifications be made to the extended aeration sewage treatment plants with subsequent evaluation of their effectiveness. The recommended modifications are to:

1. Install baffles, a submerged outlet or the equivalent to retain floating matter in the aeration tank.
2. Use hypochlorinators that periodically apply hypochlorite solution to the wet well and control chlorine dosage on the basis of the hydraulic load.
3. Provide an effective grease trap in the waste line from the galley, and provide periodic maintenance and cleaning.
4. Interconnect multiple sewage treatment plants where feasible.

5. Provide effective skimming devices for the settling tanks.
6. Provide air diffusers that are removable for inspection and replacement without draining the aeration tank.
7. Provide storage for grease and waste sludge for subsequent disposal at shore facilities.

CHANGES IN OPERATIONS

The recommended changes in operations are to:

1. Provide routine maintenance and cleaning of treatment plants and accessory equipment.
2. Provide treatment for all sanitary wastes including dishwasher, galley, shower, and laundry wastes.
3. Provide a stock of spare comminutor, chlorinator, blower, pump, and diffuser parts aboard for immediate repair and/or replacement of defective parts.

PERFORMANCE SPECIFICATIONS

The manufacturers or suppliers of the sewage treatment equipment should be required to:

1. Meet a performance specification which should be included in the purchase contract.
2. Provide regular inspections of the plant operations for a minimum of one year.

3. Train Corps of Engineer personnel in proper plant operating techniques. Provide acceptable operating manuals to the U. S. Corps of Engineers.

ROUTINE TESTING

To evaluate the operating conditions of the treatment plants it is recommended that:

1. Chlorine residual be determined on the effluent at least three times daily.
2. The volume of floc and the light penetration test on the effluent and liquid in the aeration tank be determined daily.
3. Biochemical Oxygen Demand, Total Suspended Solids, and total and fecal coliforms be determined on samples collected on a regular schedule. A recommended schedule is one time per week for the first two months of operation and bi-weekly thereafter.
4. The clarity of effluent be observed several times per day.

EXTENDED AERATION SEWAGE TREATMENT ON U. S. CORPS OF ENGINEERS DREDGES

INTRODUCTION

Sewage treatment equipment, mostly central or package type macerator/chlorinator units, have been placed on 212 Corps of Engineers vessels. Eight vessels are equipped with incinerator type treatment units and 12 are equipped with aerobic type treatment plants. The aerobic type treatment units on three vessels were studied and are the subject of this report. Studies were requested by the U. S. Corps of Engineers and in accordance with Executive Order 11288. Joint studies were initiated between the Corps of Engineers and the Federal Water Pollution Control Administration with the information gained to be used by both agencies.

The evaluation of sewage treatment on vessels present problems that are different from those associated with municipal sewage treatment. Major differences aboard vessels include: (1) shorter sewers that reduce time of passage, mixing and sewage septicity; (2) extreme flow variations that range from high rates to no flow; (3) wastewater quality variations among vessels that in some cases includes salt water additions; (4) restriction in plant size to fit available space; (5) insufficient attention directed towards plant operation.

OBJECTIVES OF STUDY

1. To determine wastewater quality and quantity to and from extended aeration type sewage treatment units, and component wastewater streams, aboard vessels.
2. To evaluate treatment unit efficiencies.
3. To recommend required tests and procedures to evaluate aeration type treatment plant operating performance aboard vessels.

DEFINITIONS

BOD - Biochemical oxygen demand. The amount of oxygen required by aerobic bacteria in the stabilization of organic matter in a specified time and at a specified temperature. In this study, all BOD is reported for 5-days at 20°C.

Extended aeration - A sewage treatment process in which the waste, after screening or comminution, is discharged to an aeration tank. Nominal detention time in the aeration tank is greater than 24 hours. After aeration, the mixed liquor flows to a settling tank where the supernatant flows to the chlorine contact tank for chlorination and discharge, while the settled sludge is returned to the aeration chamber.

pH - The negative logarithm of the hydrogen ion concentration. It is used to express the intensity of the acid or alkaline condition of a solution.

Turbidity - The expression of an optical property of a wastewater which causes light to be scattered and absorbed rather than transmitted in straight lines through the wastes.

Light penetration - The depth at which the turbidity restricts the visual differentiation of color.

TSS - Total suspended solids. The substances largely removed from a wastewater by filtration.

Chlorine residual - The quantity of chlorine in the wastewater that is available for disinfection.

Floc - The solids in the mixed liquor from the aeration tank which will subside in quiescent conditions in one hour.

mg/l - Milligrams per liter.

PROCEDURES

FLOW MEASUREMENT

Determination of the effluent flows was based on the effluent pump cycle during which a constant liquid volume was discharged overboard. The total daily flow was determined from the number of pump cycles and the volume per cycle. Instantaneous rates were based on the interval between pump cycles and the volume per cycle.

Two types of recorders were used: The first recorded the water level in the holding tank (Fig. 1). The slope of the line shows the rate of increase in depth, but because of variations in tank dimensions as the depth increases, complex formulas and equations would be required to determine the instantaneous flows. The second was an event recorder that indicated when a pump was operating (Fig. 2). Both of these recorders indicate the time between pump cycles which was required to make computations. A quantitative measurement of the influent flow was not made. Water usage for the sanitary water system was measured with a water meter.

Existing piping prohibited the measurement of flows from the galley, dishwasher, laundry and shower. Waste quantities from these sources were estimated.

Investigations have shown (Metcalf and Eddy, 1916) that the weight of feces from men is approximately three times that of women and the weight of urine from men is approximately 10 percent greater

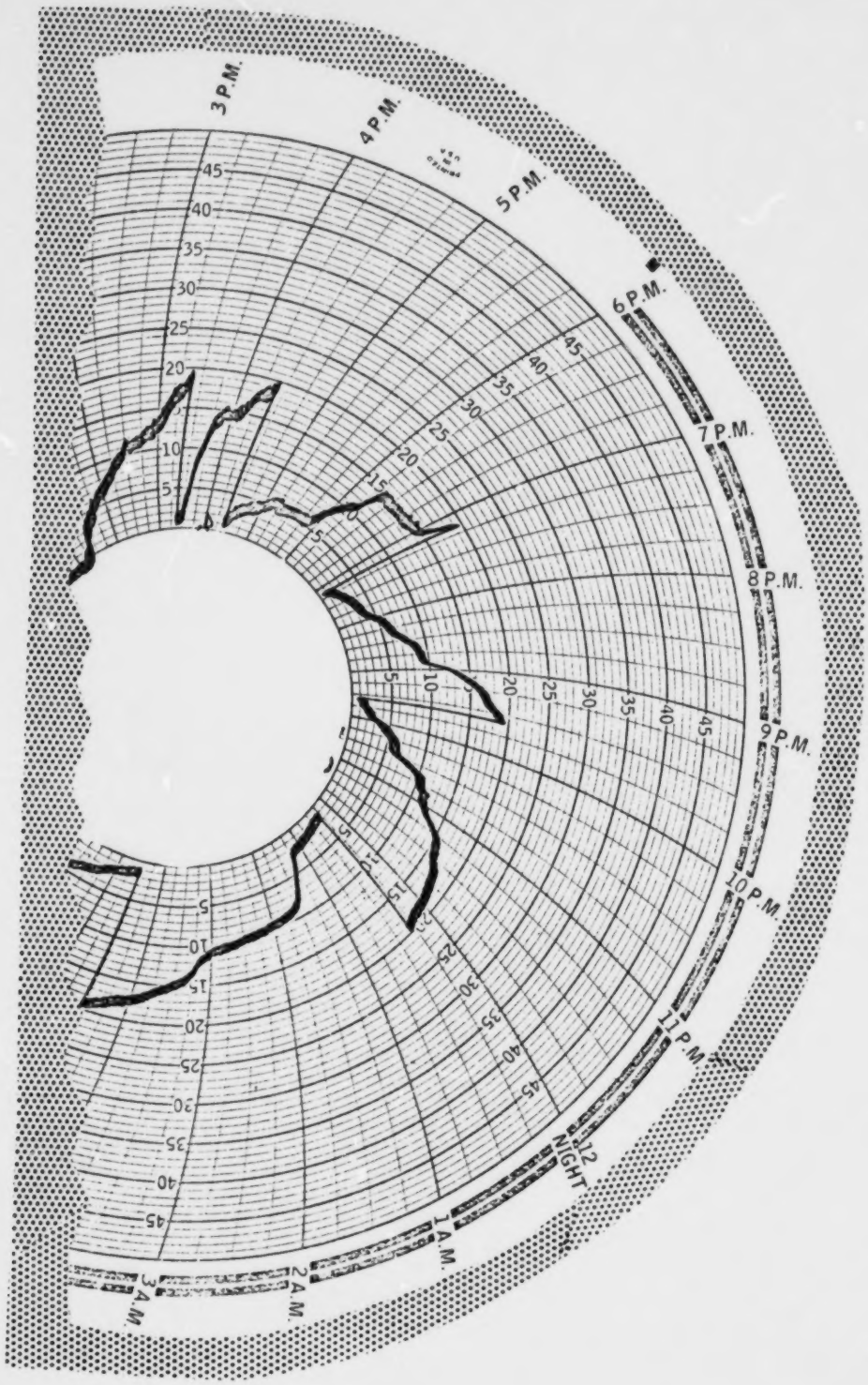

Figure 1. Chart from Pneumatic Recorder.

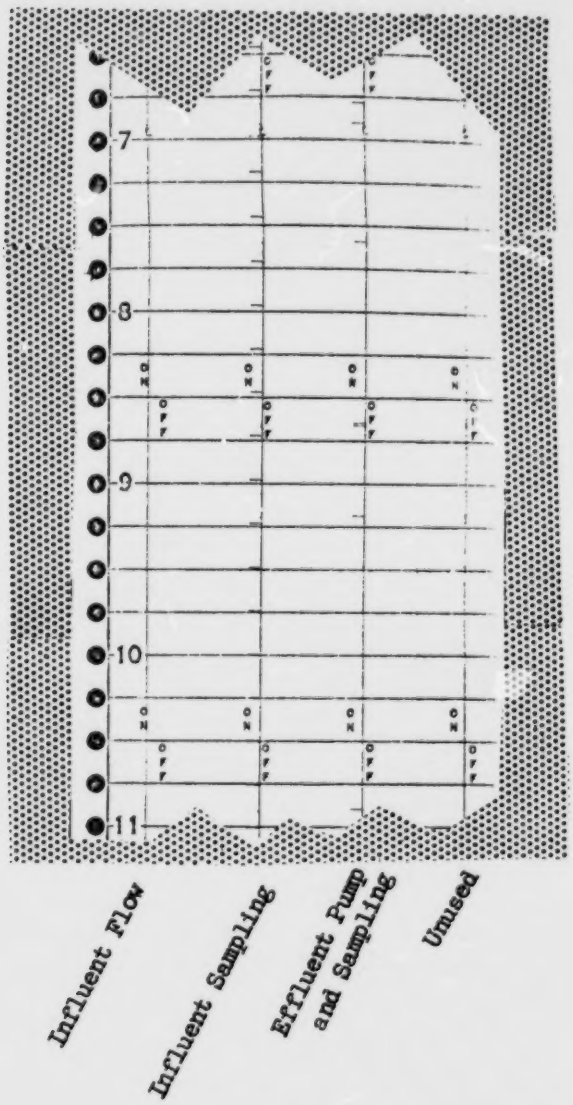

Figure 2. Chart from Event Recorder.

than that from women. The amount of toilet wastes on a dredge with only men would probably be greater than in a family community. Cla. and Viesman (1965) gave an approximate division of flow per capita per day based on total domestic wastes in private dwellings. Because most of the laundry was done on shore rather than aboard the vessel, adjustments were made to these estimates (Table 1).

Table 1. APPROXIMATE DIVISION OF WASTEWATER FLOW

Water Use	Estimated % of Volume	
	Clark and Viesman	Adjusted
kitchen	20	20
toilet	25	35
shower	25	25
wash basin	10	10
laundry	20	10

The dishwasher and/or dishwashing portion of the water usage would be approximately five percent of the total flow, or one-fourth of the water used in the galley.

SAMPLING

To observe variations in treatment, operations, and effluent quality each treatment plant was sampled for a period of ten days.

Effluent samples were collected with an automatic sampling device as indicated in the following diagram.

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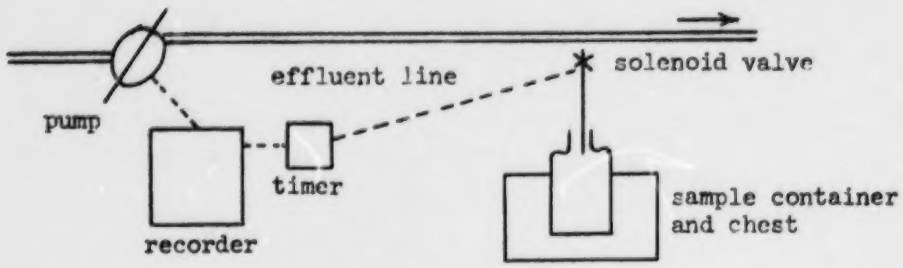
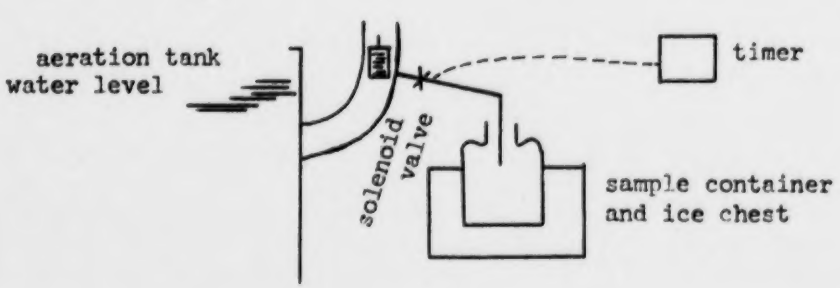


After one of the dual effluent pumps operated for 10 seconds, the solenoid valve opened automatically and a portion of the flow was diverted into the iced sample container. In addition to the composite sample, which was proportional to flow over the 24-hour period, three grab samples were collected daily.

Influent samples were obtained from the discharge of the comminutor as indicated in the following diagram.



Once every 15 minutes, when the inflow was over 1 gpm, the solenoid valve opened automatically and a portion of the flow was diverted into the iced sample container. The sample volume was not directly proportional to the rate of inflow. The sample pipe was inserted in the aeration tank influent pipe below the center of the comminutor.

Sample valves and service lines were opened manually, and the waste allowed to thoroughly rinse the lines before samples were collected for bacteriological analyses.

The laundry wastes were sampled manually, but no flows were determined. An individual home-type washer was used on the dredges. The galley wastes were collected in a common line, the contents of which were sampled manually. The shower wastes were sampled with a constant volume automatic sampler.

LABORATORY ANALYSES

Laboratory analyses, including biochemical oxygen demand (BOD), total suspended solids (TSS), temperature, pH and chlorine residual, were performed according to the methods and procedures in the 12th Edition of Standard Methods 1965, except where modifications are indicated. Some effluent samples were allowed to settle for one hour. The supernatant siphoned off and the BOD and total suspended solids were determined to ascertain the effects of additional settling and vessel vibration. Chlorides were determined on all samples when a dredge was in salt water, and on three sets

of the samples when the dredge was in fresh water, to evaluate the effects of chlorides on treatment plant performance and to check for interconnections among various waste sources.

The oxygen demand index (ODI) was a colorimetric modification of the chemical oxygen demand (COD) test. The oxidation of organic material is not as complete as in the COD determination. However, the material oxidized in the ODI test approximates the material biologically oxidized in the BOD test. The test was performed to establish a method to evaluate the operation of the extended aeration sewage treatment plants, and to approximate the BOD to indicate dilutions for the BOD analyses.

The relative stability test was evaluated as a test that Corps of Engineers personnel could use to evaluate the performance of extended aeration sewage treatment plants.

The volume of floc and light penetration measurements were made on the effluent and mixed liquor samples. Samples from the aeration tank and the plant effluent were settled for one hour in a one-liter graduated cylinder and the volume of the settleable material was measured. From these values the volumetric percent of floc was determined. The light penetration of the two samples was then determined. A black and white disc was lowered through the supernatant until the pattern was indistinguishable. The depth of the disc in the one-liter graduate was recorded as depth of light penetration. A sample with less turbidity and less colloidal and

Table 2. COMPARISON OF SEWAGE TREATMENT PLANT DIMENSIONS

	Aeration Tank				Settling Tank*			Cl_2 Contact Tank
Dredge Name	Water Depth (ft)	Length (ft)	Width (ft)	Capacity (gallons)	Length (ft)	Width (ft)	Capacity (gallons)	Capacity (gallons)
McFarland	6	9.3	4	1650	4	4	500	110
Gerig	5.5	9	4.8	1800	2	4.8	330	120
Guthrie	3.8	8.8	4.8	1200	3.8	4.8	300	120
Guthrie (heat accelerated)	3.8	3	4.8	470	3.8	4.8	300	120

Note: The tanks were not of uniform cross-section, therefore volumes had to calculated from plant drawings, and the product of tabulated length, width and depth does not equal the tabulated volume.

* Length of tank was with respect to direction of sewage flow.

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suspended matter has a deeper penetration of light. A clear sample would not restrict light penetration and the maximum depth reading would result.

Bacteriological analyses were made for the coliform group. The tests used were the multiple-tube fermentation technique (MPN) and the membrane filter technique (MF). The MPN technique is the classical one for expressing coliform densities. The total coliforms determined by the MF method and by the confirmed test of the MPN method are similar but not equal. Similarly, the fecal coliform results from both methods should not be equated. There is no absolute correlation between the two techniques.

The MF results are based on actual colony counts while the MPN results are index numbers that are statistical estimates. The index numbers are the median values based on the probability that the results are within 95 percent confidence limits.

WASTE TREATMENT FACILITIES

Waste and waste treatment systems were studied on the hopper Dredge McFarland, hopper Dredge Gerig and the pipeline Dredge Guthrie.

Potable water was used for drinking, food preparation and dish washing. Sanitary water, used for the toilet facilities or deck washing, was taken from the river or bay. Water needed for boilers, heaters, engine cooling and other miscellaneous uses was not considered in this report.

The sewage treatment plants were of similar design. Wastewaters were passed through continuously rotating comminutors. Sludge collected in the hopper bottoms of the settling tanks was returned to the aeration compartments by air lift pumps. The plants had two effluent pumps that discharged at the water level. None of the plants had provisions to waste sludge.

The dredges McFarland and Gerig had two sewage treatment plants each with independent collection systems. A comparison of dimensions of treatment plant units is presented in Table 2.

DREDGE MCFARLAND

Remarks

The rate at which sludge was returned to the aeration tank was approximately five times the raw waste flow.

The aeration tank was originally equipped with air-comb diffusers that lasted approximately one year and then were replaced with 1-inch plastic pipe nozzles. The aeration tank had to be drained overboard to permit replacement of the diffusers.

The skimming devices on the final settling tanks were plugged and the tanks contained large quantities of grease. Neither plant was equipped to retain floating materials in either the aeration or the final settling tanks.

In February, 1968, the treatment plant manufacturer's representative adjusted the chlorinator to provide a 1 mg/l chlorine residual in the effluent. However, potable water was used in making the adjustment and the chlorine demand of the sewage was ignored, thus the 1 mg/l chlorine residual was not obtained during plant operation.

Discussion of Results

A summary of the data from the port sewage treatment plant is shown in Tables 3 to 6. The maximum BOD and total suspended solids (1650 and 1510 mg/l respectively) in the port influent grab samples indicated the increased load of galley wastes on the plant.

Table 3

Chemical and Physical Sampling Data

U. S. Corps of Engineers Dredge McFarland
Port Sewage Treatment Plant
Influent Samples

Station 21

	Flow GPD	pH	BOD mg/l	BOD lb/day	ODI mg/l	TSS mg/l	TSS lb/day	Turb	Chlorides mg/l
Grab									
Average	1440	7.1	940	10.6	900	980	12.2	340	8900
Maximum	3330	7.6	1650	20.3	1450	1510	31.3	560	10800
Minimum	580	5.9	460	2.3	220	490	2.7	140	7500
Number	26	22	26	26	26	26	26	24	26
Composite									
Average	1090	7.1	1060	9.2	980	1190	10.4	390	8800
Maximum	1350	7.6	1690	14.7	1450	1510	12.1	700	9400
Minimum	940	6.7	560	4.9	610	700	6.1	150	7960
Number	9	8	8	8	8	8	8	7	8

12-A

Table 4

Bacteriological Sampling Data

U. S. Corps of Engineers Dredge McFarland
Port Sewage Treatment Plant
Influent Samples

Station 21

	Total Coli MF/100 ml	Fecal Coli MF/100 ml
Grab		
Mean	8.300,000	840,000
Maximum	85,000,000	22,000,000
Minimum	1,000,000	130,000
Number	20	20

12-B

Table 5

Chemical and Physical Sampling Data

U. S. Corps of Engineers Dredge McFarland
Port Sewage Treatment Plant
Effluent Samples

Station 22

	Flow GPD	pH	BOD mg/l	BOD lb/day	ODI mg/l	TSS mg/l	TSS lb/day	Turb	Chlorides mg/l	CL2 Res mg/l
Grab										
Average	1210	7.4	450	4.5	970	1340	12.7	110	8500	0.0
Maximum	3330	7.8	2560	29.0	5500	9100	103.2	190	9400	0.0
Minimum	580	6.9	96	0.6	100	120	0.8	37	7500	0.0
Number	27	22	17	17	26	26	26	23	26	27
Composite										
Average	1090	7.4	63	0.6	460	400	3.6	110	8500	
Maximum	1350	8.5	170	1.6	980	1080	10.3	360	9100	
Minimum	940	6.1	3	0.0	150	120	1.1	34	7800	
Number	9	8	4	4	8	8	8	8	8	

12-C

Table 6

Bacteriological Sampling Data

U. S. Corps of Engineers Dredge McFarland — Station 22
Port Sewage Treatment Plant
Effluent Samples

	Total Coli MF/100 ml	Fecal Coli MF/100 ml
Grab		
Mean	870,000	78,000
Maximum	23,000,000	1,500,000
Minimum	30,000	2,000
Number	21	21

12.0

Comparisons of the average results on the influent composite and grab samples (Table 3), show a 13 and 21 percent higher concentration of BOD and TSS respectively in the composite samples, but a higher loading rate in the grab samples (15 percent and 17 percent).

The pH of the influent dropped to 5.9 on one day but the remainder of the values were between 6.0 and 8.0.

Results from samples of the port sewage treatment plant effluent (Table 5) show erratic performance of this plant; the BOD ranged from 96 to 2560 mg/l, and the TSS ranged from 120 to 9100 mg/l. The results from the composite samples show lower concentrations and loadings of BOD and TSS than the rated loadings calculated from the grab sample data. Based on the results from the composite samples, reductions through the plant ranged from 71.2 to 99.5 percent for BOD, and from 12.9 to 90.4 percent for TSS (Table 7). Reductions in total and fecal coliforms were very low (Tables 4 and 6).

A summary of the data from the starboard sewage treatment plant is shown in Tables 8 to 11. The influent BOD and TSS concentrations were comparable to those from the port plant (Tables 3 and 8). However, the instantaneous flow rates corresponding to the grab samples collected between 0600 and 1000 hours were higher than the daily average for both treatment plants, indicating a peak load to the treatment plants during that time.

Table 7

Sewage Treatment Sampling Data

U. S. Corps of Engineers Dredge McFarland — Station 22
Port Sewage Treatment Plant

Date	Influent BOD lb/day	Influent TSS lb/day	Influent Flow GPD	Effluent BOD lb/day	Effluent TSS lb/day	Reduction BOD Percent	Reduction TSS Percent	Men
3/ 7/68			1,350					68
3/ 8/68	8.7	11.9	1,140		1.1		90.4	68
3/ 9/68	8.9	11.8	940	0.2	2.4	97.6	80.1	58
3/10/68	4.9	9.8	1,040	0.0	2.3	99.5	77.0	66
3/11/68	7.9	10.8	1,040		6.3		41.6	67
3/12/68	14.5	9.1	1,040	0.5	2.9	96.8	67.6	66
3/13/68	8.4	6.1	1,040		2.1		65.7	65
3/14/68	14.7	12.1	1,040		1.2		90.0	65
3/15/68	5.6	11.8	1,140	1.6	10.3	71.2	12.9	65

B-A

Table 8

Chemical and Physical Sampling Data

U. S. Corps of Engineers Dredge McFarland
Starboard Sewage Treatment Plant
Influent Samples

Station 23

	Flow GPD	pH	BOD mg/l	BOD lb/day	ODI mg/l	TSS mg/l	TSS lb/day	Turb	Chlorides mg/l
Grab									
Average	1410	8.1	760	8.2	750	770	9.1	260	9300
Maximum	4990	8.4	1820	34.9	1410	1420	41.2	620	11100
Minimum	200	7.7	120	1.3	160	150	1.5	74	7350
Number	26	22	26	26	26	26	26	24	26
Composite									
Average	1030	7.9	690	5.8	840	860	7.3	180	9400
Maximum	1250	8.6	1330	12.6	1410	1410	13.4	364	10700
Minimum	730	7.3	190	2.0	280	160	1.1	60	8350
Number	9	8	8	8	8	8	8	8	8

Table 9

Bacteriological Sampling Data

U. S. Corps of Engineers Dredge McFarland
Starboard Sewage Treatment Plant
Influent Samples

Station 23

	Total Coli MF/100 ml	Fecal Coli MF/100 ml
Grab		
Mean	500,000	310,000
Maximum	2,400,000	1,300,000
Minimum	190,000	110,000
Number	18	21

13-C

Table 10

Chemical and Physical Sampling Data

U. S. Corps of Engineers Dredge McFarland
Starboard Sewage Treatment Plant

Station 24

Effluent Samples

	Flow GPD	Temp C	pH	BOD mg/l	BOD lb/day	ODI mg/l	TSS mg/l	TSS lb/day	Turb	Chlorides mg/l	CL2 Res mg/l
Grab											
Average	1670	17	7.7	490	4.3	490	230	2.7	68	8700	0.0
Maximum	7490	17	8.2	1820	34.9	1410	860	16.5	276	9350	0.0
Minimum	200	17	6.3	30	0.4	50	90	0.3	25	8150	0.0
Number	27	2	23	12	12	27	27	27	25	27	27
Composite											
Average	1030		7.8	780	7.1	1020	700	7.0	110	8800	
Maximum	1250		8.4	1460	15.2	3650	4540	47.3	540	9450	
Minimum	730		7.1	40	0.4	450	100	1.0	27	8000	
Number	9		8	3	3	8	8	8	8	8	

13.D

Table 11

Bacteriological Sampling Data

U. S. Corps of Engineers Dredge McFarland
Starboard Sewage Treatment Plant
Effluent Samples

Station 24

	Total Coli MF/100 ml	Fecal Coli MF/100 ml
Grab		
Mean	14.000	4,400
Maximum	270,000	33,000
Minimum	100	10
Number	21	21

13.F

The quality of the effluent from the starboard plant was erratic. Concentrations of the BOD and TSS ranged from 30 to 1820 mg/l and 90 to 860 mg/l respectively (Table 10).

The reduction of TSS ranged from zero to 89.4 percent and was less than in the port plant (Table 12).

The water pumped aboard for use in the sanitary facilities was determined to have no BOD and only 1.6 lb TSS/Day (Table 13). No bacteriological tests were made on this water supply.

DREDGE GERIG

Remarks

Each aeration tank had six self-cleaning Link-Belt air diffusers mounted on each of two manifolds. The condition of the diffusers was not inspected during the study.

The wastes flowed over a weir into the settling tank with no means to retain floating solids in the aeration or settling tank or to reduce turbulence caused by the overflow to the settling tank.

The plant was designed to use a HTH (calcium hypochlorite) mixture for chlorination. The lines were clogged; therefore, no chlorine was added to the effluent during the study.

Table 12

Sewage Treatment Sampling Data

U. S. Corps of Engineers Dredge McFarland — Station 24
Starboard Sewage Treatment Plant

Date	Influent BOD lb/day	Influent TSS lb/day	Influent Flow GPD	Effluent BOD lb/day	Effluent TSS lb/day	Reduction BOD Percent	Reduction TSS Percent	Men
3/ 7/68			1,140					68
3/ 8/68	2.0	3.8	1,250	15.2	47.3	-670.	-1160.	68
3/ 9/68	2.9	3.2	940		1.3		58.5	58
3/10/68	3.5	7.5	940		1.3		82.3	66
3/11/68	8.6	13.4	1,140		1.4		89.4	67
3/12/68	5.8	1.1	830	5.8	1.1	0.0	0.0	66
3/13/68	5.7	8.5	730		1.0		88.5	65
3/14/68	12.6	8.0	1,140		1.0		88.5	65
3/15/68	5.1	12.9	1,140	0.4	1.7	92.6	86.8	65

M-4

Table 13

Chemical and Physical Sampling Data

U. S. Corps of Engineers Dredge McFarland
Sanitary Water Samples

Station 29

	Flow GPD	pH	BOD mg/l	BOD lb/day	ODI mg/l	TSS mg/l	TSS lb/day	Turb	Chlorides mg/l
Grab									
Average	1890	8.0	2	0.0	470	260	4.0	130	12600
Maximum	2500	8.5	4	0.1	630	1360	20.5	730	16250
Minimum	1460	7.5	1	0.0	350	20	0.3	1	1170
Number	9	6	5	5	6	6	6	6	6

IV-B

Discussion of Results

Results from the influent samples from the fore plant (Table 14) show that the BOD and TSS were higher (57 percent and 112 percent respectively) for the composited samples than for those grab samples collected between 0600 and 1000 hours, indicating that peak loads occurred outside this period.

Reductions in BOD and TSS varied from 40 to 82.9 percent and from 4.0 to 78.1 percent respectively (Table 18). There was an additional 45 percent reduction in BOD when the analysis was performed on the supernatant of a sample that had settled for one hour. This analysis was performed to determine if improved settling would result in better effluent quality.

The grab samples of the influent from the aft sewage treatment plant, which included wastes from the galley, had BOD concentrations ranging from 220 to 1,670 mg/l, and TSS ranging from 75 to 5,000 mg/l (Table 19). The volume of flow and the TSS loads were higher for the grab samples collected between 0600 and 1000 hours than for the composites (2,580 to 2,140 gpd and 15.7 to 9.3 lb/day respectively), indicating peak loads occurred during that time.

The BOD reductions through the aft sewage treatment plant ranged from 48.8 to 72.0 percent and TSS reductions ranged from 7.2 percent to 77.6 percent (Table 23). An additional 20 percent removal of BOD was obtained when the BOD analysis was performed on the supernatant of an effluent sample that had settled for one hour.

Table 14

Chemical and Physical Sampling Data
U. C. Corps of Engineers Dredge Gerig
Fore Sewage Treatment Plant
Influent Samples

	Flow GPD	Temp C	pH	BOD mg/l	BOD lb/day	Settled BOD mg/l	ODI mg/l	TSS mg/l	TSS lb/day	Chlorides mg/l
Grab										
Average	2,030	25	8.0	210	3.9	180	350	340	6.0	8,900
Maximum	6,240	30	8.3	550	28.6	410	710	650	33.8	16,500
Minimum	280	22	7.6	82	0.4	74	150	120	0.6	2,750
Number	32	32	17	32	32	5	15	32	32	32
Composite										
Average	1,590		8.2	330	4.6	220	520	720	9.0	8,600
Maximum	2,340		8.3	470	6.3	300	720	1,780	16.3	10,500
Minimum	1,100		8.0	200	1.8	130	240	250	3.7	3,500
Number	10		5	8	8	8	4	8	8	8

Table 15

Bacteriological Sampling Data

U. S. Corps of Engineers Dredge Gerig
Fore Sewage Treatment Plant

Station 41

Influent Samples

Grab	Conf. Coli MPN/100 ml	Fecal Coli MPN/100 ml	Total Coli MF/100 ml	Fecal Coli MF/100 ml
Mean	1,800,000	1,300,000	3,000,000	720,000
Maximum	24,000,000	13,000,000	15,000,000	6,200,000
Minimum	330,000	230,000	830,000	110,000
Number	32	32	9	9

15-B

Table 16

Chemical and Physical Sampling Data

U. S. Corps of Engineers Dredge Gerig
Fore Sewage Treatment Plant
Effluent Samples

Station 42

	Flow GPD	Temp C	pH	BOD mg/l	BOD lb/day	Settled BOD mg/l	ODI mg/l	TSS mg/l	TSS lb/day	Settled TSS mg/l	Turb	Chlorides mg/l	CL2 Res mg/l
Grab													
Average	2240	24	7.5	84	1.6	46	220	210	4.0		59	6600	0.1
Maximum	9360	28	7.8	190	11.7	62	390	630	35.9		140	9050	0.2
Minimum	280	21	7.3	35	0.1	38	50	52	0.1		17	4000	0.0
Number	32	32	17	32	32	5	14	32	32		32	32	32
Composite													
Average	1610		7.6	87	1.1	48	240	260	3.5	51	74	6700	
Maximum	2340		8.1	120	1.8	63	280	390	6.6	57	130	8500	
Minimum	1100		7.3	38	0.6	19	160	170	2.6	47	43	4150	
Number	10		5	10	10	9	4	10	10	3	10	10	

Table 17

Bacteriological Sampling Data

U. S. Corps of Engineers Dredge Gerig Station 42
Fore Sewage Treatment Plant

Effluent Samples

	Conf. Coli MPN/100 ml	Fecal Coli MPN/100 ml	Total Coli MF/100 ml	Fecal Coli MF/100 ml
Grab				
Mean	450,000	320,000	800,000	38,000
Maximum	5,400,000	3,500,000	37,000,000	130,000
Minumum	49,000	46,000	150,000	6,400
Number	30	30	9	9

Table 18

Sewage Treatment Sampling Data

U. S. Corps of Engineers Dredge Gerig
Fore Sewage Treatment Plant

Station 42

Date	Influent BOD lb/day	Influent TSS lb/day	Influent Flow GPD	Effluent BOD lb/day	Effluent TSS lb/day	Reduction BOD Percent	Reduction TSS Percent	Men
4/23/68	6.3	9.7	1,760	1.4	3.4	77.2	65.2	84
4/24/68	6.2	9.0	2,340	1.8	6.6	71.9	26.1	85
4/25/68	5.9	11.1	2,210	1.4	3.9	76.6	65.0	84
4/26/68	2.9	3.7	1,760	1.3	3.5	55.5	4.0	46
4/27/68			1,240	0.7	2.6			43
4/28/68			1,240	0.9	2.8			43
4/29/68	1.8	16.3	1,100	1.1	3.6	40.0	78.1	46
4/30/68	4.6	8.2	1,170	1.2	2.8	74.5	65.5	81
5/ 1/68	5.6	9.4	1,430	1.0	2.9	81.3	69.6	85
5/ 2/68	3.4	4.6	1,820	0.6	2.6	82.9	43.8	84

Table 19. Chemical and Physical Sampling Data

U. S. Corps of Engineers Dredge Gerig Station 43
Aft Sewage Treatment Plant
Influent Samples

	Flow GPD	Temp C	pH	BOD mg/l	BOD lb/day	Settled BOD mg/l	ODI mg/l	TSS mg/l	TSS lb/day	Chlorides mg/l
Grab										
Average	2,580	29	7.3	540	11.2	140	660	800	15.7	6,600
Maximum	6,240	34	8.3	1,670	39.0	590	1,570	5,000	97.6	16,500
Minimum	380	25	6.2	220	1.8	16	230	75	1.7	850
Number	31	29	16	29	29	8	13	28	28	31
Composite										
Average	2,140		7.2	590	10.8	460	713	520	9.3	8,300
Maximum	2,540		7.4	840	16.1	630	880	830	14.0	11,500
Minimum	1,620		7.1	430	6.1	320	560	114	2.3	2,050
Number	10		3	8	8	8	3	8	8	9

15-1

Table 20

Bacteriological Sampling Data

U. S. Corps of Engineers Dredge Gerig
Aft Sewage Treatment Plant

Station 43

Influent Samples

Grab	Conf. Coli MPN/100 ml	Fecal Coli MPN/100 ml	Total Coli MF/100 ml	Fecal Coli MF/100 ml
Mean	16,000,000	4,600,000	15,000,000	1,700,000
Maximum	460,000,000	54,000,000	280,000,000	31,000,000
Minimum	20,000	20,000	100,000	10,000
Number	26	28	7	7

9-6

Table 21

Chemical and Physical Sampling Data

U. S. Corps of Engineers Dredge Gerig
Aft Sewage Treatment Plant
Effluent Samples

Station 44

	Flow GPD	Temp C	pH	BOD mg/l	BOD lb/day	Settled BOD mg/l	ODI mg/l	TSS mg/l	TSS lb/day	Settled TSS mg/l	Turb	Chlorides mg/l	CL2 Res mg/l
Grab													
Average	2670	27	7.0	200	4.3	210	320	280	5.8		94	7300	0.3
Maximum	6240	30	7.3	470	9.2	420	540	660	12.9		170	12500	2.5
Minimum	380	24	6.8	90	0.6	120	240	90	0.8		43	2050	0.0
Number	31	31	16	31	31	4	13	31	31		31	31	28
Composite													
Average	2140		7.1	200	3.5	160	340	410	7.0	300	120	7100	
Maximum	2540		7.2	260	5.4	220	370	840	13.0	300	175	10500	
Minimum	1620		7.0	140	2.4	120	320	150	3.0	300	68	3450	
Number	10		4	9	9	9	5	9	9	1	9	9	

Table 22

Bacteriological Sampling Data

U. S. Corps of Engineers Dredge Gerig
AFT Sewage Treatment Plant
Effluent Samples

Station 44

	Conf. Coli MPN/100 ml	Fecal Coli MPN/100 ml	Total Coli MF/100 ml	Fecal Coli MF/100 ml
Grab				
Mean	2,000,000	790,000	330,000	19,000
Maximum	24,000,000	22,000,000	23,000,000	1,600,000
Minimum	20	200	100	10
Number	24	27	8	8

15-L

Table 23

Sewage Treatment Sampling Data

U. S. Corps of Engineers Dredge Gerig
Aft Sewage Treatment Plant

Station 44

Date	Influent BOD lb/day	Influent TSS lb/day	Influent Flow GPD	Effluent BOD lb/day	Effluent TSS lb/day	Reduction BOD Percent	Reduction TSS Percent	Men
4/23/68			1,690	2.4	11.8			84
4/24/68	10.0	13.4	2,400	2.8	3.0	72.0	77.6	85
4/25/68	14.2	14.0	2,020	4.2	13.0	70.2	7.2	84
4/26/68	8.6	8.6	2,400	4.4	6.0	48.8	30.2	46
4/27/68	6.1	7.2	1,620	2.4	4.7	60.0	34.9	43
4/28/68	10.2	8.0	2,540	3.4	5.3	66.7	34.2	43
4/29/68	8.3	12.8	1,950	3.3	5.5	60.8	57.0	46
4/30/68	12.7	8.0	2,140	3.6	5.2	71.8	35.6	81
5/ 1/68	16.1	2.3	2,470	5.4	8.7	66.7	-270.	85
5/ 2/68			2,210					84

15-4

No BOD and only 0.2 lb/day TSS were added by the use of bay water for sanitary facilities (Tables 24 and 25). This water was the predominate source of chlorides added to the sewage treatment plants.

DREDGE GUTHRIE

Remarks

The air diffuser assemblies were three 1-1/2 inch pipes with a series of cutouts.

There was no grease or floating solids on the surface of the final settling tank.

The chlorine contact tank was baffled to eliminate short-circuiting but chlorine was not added until the flow had traveled two-thirds the length of the tank, permitting the possibility of insufficient chlorine contact time.

Discussion of Results

A summary of the data is given in Tables 26 to 29. The results indicate a peak load to the sewage treatment plant during the period 0700 to 1000 hours. Because the galley wastes were discharged overboard the composite influent sample had lower BOD and TSS concentrations than waste from the other dredges studied.

The chlorine residual ranged from 0.0 to 5.0 mg/l because there was a malfunction of the chlorinator. The BOD reduction ranged from 1.8 percent to 60.0 percent, and the highest suspended

Table 24

Chemical and Physical Sampling Data

U. S. Corps of Engineers Dredge Gerig — Station 57

Sanitary Water Samples

	Flow GPD	Temp C	pH	BOD mg/l	BOD lb/day	ODI mg/l	TSS mg/l	TSS lb/day	Chlorides mg/l
Grab									
Average	2140	18	8.0	0	0.0	170	15	0.3	12,000
Maximum	3460	21	8.1	1	0.0	275	22	0.4	18,700
Minimum	1460	15	8.0	0	0.0	71	2	0.0	3,500
Number	11	2	2	3	3	2	3	3	3

N-4

Table 25

Bacteriological Sampling Data

U. S. Corps of Engineers Dredge Gerig
Sanitary Water Samples

Station 57

Grab	Conf. Coli MPN/100	Fecal Coli MPN/100 ml
Mean	180	51
Maximum	3,500	2,400
Minimum	13	2
Number	3	3

Table 26

Chemical and Physical Sampling Data

U. S. Corps of Engineers Dredge Guthrie — Station 61

Influent Samples

	Flow GPD	Temp C	pH ___	BOD mg/l	BOD lb/day	ODI mg/l	TSS mg/l	TSS lb/day	Chlorides mg/l
Grab									
Average	2160	24	6.8	200	3.4	200	240	4.1	24
Maximum	6350	38	8.2	620	11.4	490	910	16.7	48
Minimum	980	20	3.7	33	0.4	48	18	0.5	5
Number	30	27	27	30	30	12	30	30	6
Composite									
Average	2170		6.6	130	2.2	160	120	2.1	26
Maximum	2670		7.3	180	3.1	180	180	3.0	26
Minimum	1500		6.1	56	1.0	140	75	1.3	26
Number	9		8	9	9	3	9	9	1

12.2

Table 27

Bacteriological Sampling Data

U. S. Corps of Engineers Dredge Guthrie
Influent Samples

Station 61

Grab	Conf. Coli MPN/100 ml	Fecal Coli MPN/100 ml
Mean	4,800,000	4,100,000
Maximum	92,000,000	92,000,000
Minimum	490,000	330,000
Number	29	29

12-0

Table 28

Chemical and Physical Sampling Data

U. S. Corps of Engineers Dredge Guthrie
Effluent Samples

Station 62

	Flow GPD	Temp C	pH	BOD mg/l	BOD lb/day	Settled BOD mg/l	ODI mg/l	TSS mg/l	TSS lb/day	Turb	Chlorides mg/l	CL2 Res mg/l
Grab												
Average	2,300	24	7.4	50	0.9		69	78	1.5	48	25	1.3
Maximum	6,350	27	8.0	95	2.1		110	140	5.8	73	34	5.0
Minimum	980	21	6.3	25	0.3		34	38	0.5	23	16	0.0
Number	30	27	27	30	30		12	30	30	30	6	30
Composite												
Average	2,170		7.3	74	1.4	52	93	140	2.7	63	32	
Maximum	2,620		7.7	92	1.8	70	93	260	5.4	83	32	
Minimum	1,500		6.9	55	1.0	40	93	64	1.1	45	32	
Number	9		6	6	6	5	1	6	6	6	1	

E-12

Table 29

Bacteriological Sampling Data

U. S. Corps of Engineers Dredge Guthrie
Effluent Samples

Grab	Conf. Coli MPN/100 ml	Fecal Coli MPN/100 ml
Mean	14,000	8,300
Maximum	16,000,000	16,000,000
Minimum	40	20
Number	26	27

solids reduction was 43.3 percent (Table 30). The TSS in the effluent was greater than in the influent for three days of the study. The loss of solids from the system could have been caused by surges in the flow rate, or denitrification within the system, or excessive vessel vibration. An additional 30 percent reduction of BOD was obtained when BOD's were determined on the supernatant of effluent samples that had been settled for one hour.

The 760 gallons per day of water pumped aboard for the sanitary facilities added 0.5 pound TSS and zero BOD (Tables 31 and 32).

DREDGE GUTHRIE (Heat Accelerated Operation)

Remarks

The objective of the heat accelerated operation was to raise the temperature in the aeration tank to 110°F, to increase the rate of waste decomposition and stabilization, to reduce the required oxidation period, and to reduce the required size of treatment facilities.

The modifications included installation of a partition in the aeration tank to reduce the capacity by two-thirds and the installation of an electric heater in the aeration tank. The modifications were made by the original designers and builders of the treatment plant.

The heater was not of the proper size and a temperature of only 100°F was achieved.

Table 30

Sewage Treatment Sampling Data

U. S. Corps of Engineers Dredge Guthrie — Station 62

Date	Influent BOD lb/day	Influent TSS lb/day	Influent Flow GPD	Effluent BOD lb/day	Effluent TSS lb/day	Reduction BOD Percent	Reduction TSS Percent	Men
5/15/68	3.0	3.0	2,020	1.5	2.0	48.9	33.3	41
5/16/68	2.0	1.6	1,500					44
5/17/68	2.6	2.6	2,100					39
5/18/68	2.3	2.0	2,500	1.8	5.4	20.0	-171.	38
5/19/68	3.1	2.5	2,480	1.5	1.4	50.7	43.3	41
5/20/68	2.4	1.8	1,950	1.0	2.1	60.0	-18.2	42
5/21/68	1.9	1.8	2,620	1.6	4.2	14.1	-132.	44
5/22/68	1.0	1.3	2,100	1.0	1.1	1.8	14.7	43
5/23/68	1.8	2.4	2,250					43

Table 31

Chemical and Physical Sampling Data

U. S. Corps of Engineers Dredge Guthrie

Station 69

Sanitary Water Samples

	Flow GPD	Temp C	pH	BOD mg/l	BOD lb/day	ODI mg/l	TSS mg/l	TSS mg/day	Chlorides mg/l
Grab									
Average	5630	21	7.1	1	0.0	9	85	3.1	3
Maximum	7990	23	7.5	2	0.1	15	500	15.3	4
Minimum	3677	18	6.6	1	0.0	4	11	0.4	2
Number	8	7	7	8	8	2	8	8	2

Table 32

Bacteriological Sampling Data

U. S. Corps of Engineers Dredge Guthrie
Sanitary Water Samples

Station 69

	Conf. Coli MPN/100 ml	Fecal Coli MPN/100 ml
Grab		
Mean	1,200	60
Maximum	4,900	230
Minimum	210	20
Number	8	7

12-e

Discussion of Results

A summary of the data from the sewage treatment plant with a heated aeration tank is given in Tables 33 to 36.

The highest BOD and TSS reductions were 75.5 percent and 85.3 percent respectively (Table 37). The BOD and TSS of the supernatant from settled composite effluent samples were reduced 13 percent and 36 percent respectively.

The bacteriological data are erratic because of variations up to 2.5 mg/l in chlorine residual.

The 750 gallons per day of water used for sanitary purposes added 0.1 pound TSS and zero BOD (Tables 38 and 39).

The data indicate that sewage treatment from the modified plant is as effective as from the unmodified plant, with a reduction in size and weight of the modified plant.

COMPONENT WASTE STREAMS

The five individual wastes sampled were from the galleys, dishwashers, showers, laundries and air conditioners. Volumes of flow from these sources were estimated because installation of flow measuring equipment would have required extensive modifications to the piping system.

Galley Wastes

One-tenth to two-tenths pounds per capita per day of BOD and TSS were discharged from the galley, which included wastes from

Table 33

Chemical and Physical Sampling Data

U. S. Corps of Engineers Dredge Guthrie
Influent Samples

Station 81

	Flow GPD	Temp C	pH	BOD mg/l	BOD lb/day	TSS mg/l	TSS lb/day	Chlorides mg/l
Grab								
Average	2520	30	6.1	340	7.4	320	6.7	32
Maximum	7780	46	7.9	710	22.1	970	19.3	110
Minimum	1410	26	2.3	22	0.3	11	0.1	8
Number	30	29	30	30	30	30	30	9
Composite								
Average	2140		7.3	320	5.5	320	5.8	42
Maximum	3020		9.1	440	8.3	420	8.0	46
Minimum	1510		6.7	230	3.9	180	2.5	36
Number	9		9	9	9	9	9	3

Table 34

Bacteriological Sampling Data

U. S. Corps of Engineers Dredge Guthrie
Influent Samples

Station 81

	Conf. Coli MPN/100 ml	Fecal Coli MPN/100 ml	Total Coli MF/100 ml	Fecal Coli MF/100 ml
Grab				
Mean	5,200,000	3,500,000	9,500,000	1,300,000
Maximum	160,000,000	160,000,000	78.000,000	4,300,000
Minimum	11,000	11,000	90,000	37,000
Number	22	23	5	5

Table 35

Chemical and Physical Sampling Data

U. S. Corps of Engineers Dredge Guthrie — Station 82

Effluent Samples

	Flow GPD	Temp C	pH	BOD mg/l	BOD lb/day	Settled BOD mg/l	TSS mg/l	TSS lb/day	Settled TSS mg/l	Turb	Chlorides mg/l	CL2 Res mg/l
Grab												
Average	2450	36	7.7	82	1.6		150	2.8		55	56	0.8
Maximum	7780	38	8.0	230	4.2		410	7.8		81	88	2.5
Minimum	1410	32	7.3	14	0.3		38	0.7		30	31	0.0
Number	30	30	30	30	30		30	30		30	9	30
Composite												
Average	2140		7.7	97	1.7	84	140	2.6	90	60	64	0.0
Maximum	3020		7.9	130	2.5	110	210	4.5	140	70	85	0.0
Minimum	1510		7.4	62	1.1	57	56	0.8	48	52	50	0.0
Number	9		9	9	9	9	9	9	9	9	3	9

Table 36

Bacteriological Sampling Data

U. S. Corps of Engineers Dredge Guthrie — Station 82

Effluent Samples

	Conf. Coli MPN/100 ml	Fecal Coli MPN/100 ml	Total Coli MF/100 ml	Fecal Coli MF/100 ml
Grab				
Mean	2,400	1,100	880	130
Maximum	2,400,000	2,400,000	55,000	7,500
Minimum	80	40	30	10
Number	21	19	17	13

18-C

Table 37

Sewage Treatment Sampling Data

U. S. Corps of Engineers Dredge Guthrie Station 82

Date	Influent BOD lb/day	Influent TSS lb/day	Influent Flow GPD	Effluent BOD lb/day	Effluent TSS lb/day	Reduction BOD Percent	Reduction TSS Percent	Men
6/12/68	3.9	5.1	2,050	1.1	1.7	73.0	66.7	43
6/13/68	8.3	7.5	2,380	2.1	1.1	75.2	85.3	43
6/14/68	6.3	6.8	3,020	2.3	4.5	63.6	33.3	43
6/15/68	4.0	2.5	1,510	1.1	0.8	73.4	70.0	39
6/16/68	4.4	5.6	2,050	1.9	3.4	57.7	39.4	39
6/17/68	4.1	3.2	2,160	1.6	3.2	62.2	0.0	39
6/18/68	6.3	6.1	1,730	1.6	2.3	75.0	61.9	41
6/19/68	5.9	8.0	2,270	2.5	4.0	58.1	50.0	41
6/20/68	6.5	7.2	2,050	1.6	2.7	75.5	61.9	41

D-81

Table 38

Chemical and Physical Sampling Data

U. S. Corps of Engineers Dredge Guthrie — Station 89

Sanitary Water Samples

	Flow GPD	Temp C	pH	BOD mg/l	BOD lb/day	TSS mg/l	TSS lb/day	Chlorides mg/l
Grab								
Average	1560	27	6.7	1	0.0	25	0.3	4
Maximum	2330	28	7.0	1	0.0	69	0.9	4
Minimum	1050	26	6.4	1	0.0	13	0.1	4
Number	10	10	9	9	9	9	9	3

Table 39

Bacteriological Sampling Data

U. S. Corps of Engineers Dredge Guthrie
Sanitary Water Samples

Station 89

	Conf. Coli MPN/100 ml	Fecal Coli MPN/100 ml	Total Coli MF/100 ml	Fecal Coli MF/100 ml
Grab				
Mean	870	110	400	38
Maximum	4,900	460	660	56
Minimum	170	20	240	26
Number	10	10	2	2

dishwashing, food preparation and garbage grinding (Table 40 and 41).

High densities of fecal coliform, from an unknown source, were found in the galley wastes (Table 41). No cross connection with toilet wastes was found.

Dishwasher Samples

An average BOD of 18 mg/l, with a maximum of 58 mg/l, and an average TSS of 10 mg/l were found in samples of dishwasher wastes (Tables 42 and 43). These values, although low, indicate that dishwasher wastes should be subjected to treatment.

Laundry Samples

The average BOD of 270 mg/l and TSS of 240 mg/l in the samples from the laundries are a result of the detergent used and dirt removed (Tables 44 and 45). The coliform density of only 2 MPN/100 ml is a result of the high water temperatures and the use of a chlorine bleach.

Shower Samples

Soap was the source of an average BOD of 83 mg/l and TSS of 51 mg/l with a maximum of 130 mg/l in the wastes from the showers (Table 46). The bacteriological results indicate that these wastes can be a significant source of coliforms, with 3,800 MPN/100 ml fecal coliforms present. Such wastes should be subjected to treatment including effective chlorination.

Table 40

Chemical and Physical Sampling Data

U. S. Corps of Engineers Dredge

Galley Samples

	Temp C	pH	BOD mg/l	ODI mg/l	TSS mg/l	Turb	Chlorides mg/l	CL2 Res mg/l
Grab								
Average	38	7.6	1620	930	760	370	170	0.2
Maximum	46	9.9	4810	2950	2900	820	630	1.5
Minimum	28	4.9	110	80	4	160	3	0.0
Number	28	28	32	16	35	6	23	10

Table 41

Bacteriological Sampling Data

U. S. Corps of Engineers Dredge
Galley Samples

	Conf. Coli MPN/100 ml	Fecal Coli MPN/100 ml	Total Coli MF/100 ml	Fecal Coli MF/100 ml
Grab				
Mean	12,000,000	1,800,000	67,000,000	3,100,000
Maximum	160,000,000	130,000,000	300,000,000	25,000,000
Minumum	170,000	7,900	10,000,000	610,000
Number	21	22	7	7

Table 42

Chemical and Physical Sampling Data

U. S. Corps of Engineers Dredge

Dishwasher Samples

	Flow GPD	Temp C	pH	BOD mg/l	ODI mg/l	TSS mg/l	Turb	Chlorides mg/l
Grab								
Average	79	59	8.9	18	47	10	69	220
Maximum	105	63	10.0	58	130	21	430	390
Minimum	60	56	7.8	4	0	2	0	6
Number	8	5	9	9	13	12	7	13

Table 43

Bacteriological Sampling Data

U. S. Corps of Engineers Dredge
Dishwasher Samples

	Conf. Coli MPN/100 ml	Fecal Coli MPN/100 ml	Total Coli MF/100 ml	Fecal Coli MF/100 ml
Grab				
Mean	2	2	17	2
Maximum	2	2	1,180	2
Minimum	2	2	2	2
Number	5	5	3	2

Table 44

Chemical and Physical Sampling Data

U. S. Corps of Engineers Dredge
Laundry Samples

	Temp C	pH	BOD mg/l	ODI mg/l	TSS mg/l	Turb	Chlorides mg/l	CL2 Res mg/l
Grab								
Average	54	7.9	270	480	240	210	1900	0.0
Maximum	58	9.8	680	1100	1180	450	16250	0.0
Minimum	45	6.3	4	15	0	1	0	0.0
Number	6	12	11	8	13	6	10	4

Table 45

Bacteriological Sampling Data

U. S. Corps of Engineers Dredge
Laundry Samples

	Conf. Coli MPN/100 ml	Fecal Coli MPN/100 ml
Grab		
Mean	2	2
Maximum	2	2
Minimum	2	2
Number	4	3

Table 46

Chemical and Physical Sampling Data

U. S. Corps of Engineers Dredge
Shower Samples

	pH	BOD mg/l	ODI mg/l	TSS mg/l	Turb	Chlorides mg/l
Grab						
Average	7.3	83	130	51	110	89
Maximum	7.5	110	160	130	110	350
Minimum	7.1	38	105	20	110	2
Number	5	8	2	8	1	8

Table 47

Bacteriological Sampling Data

U. S. Corps of Engineers Dredge
Shower Samples

	Conf. Coli MPN/100 ml	Fecal Coli MPN/100 ml	Total Coli MF/100 ml	Fecal Coli MF/100 ml
Grab				
Mean	21,000	3,800	640	40
Maximum	54,000	54,000	3,700	40
Minimum	7,900	340	100	40
Number	6	6	3	1

Miscellaneous Samples

The miscellaneous samples were from the air conditioner condensate on the Dredge Guthrie. This waste had a variable concentration of BOD (9 to 60 mg/l) and TSS (10 to 240 mg/l) and an insignificant coliform density (fecal coliform to 3 MPN/100 ml) (Tables 48 and 49).

Table 48

Chemical and Physical Sampling Data

U. S. Corps of Engineers Dredge
Miscellaneous Samples

	pH	BOD mg/l	ODI mg/l	TSS mg/l	Chlorides mg/l
Composite					
Average	6.7	26	47	72	3
Maximum	7.1	60	71	240	3
Minimum	6.0	9	20	10	3
Number	7	6	3	7	1

Table 49

Bacteriological Sampling Data

U. S. Corps of Engineers Dredge
Miscellaneous Samples

	Conf. Coli MPN/100 ml	Fecal Coli MPN/100 ml
Composite		
Mean	74	3
Maximum	790	20
Minimum	5	2
Number	8	7

DISCUSSION

SEWAGE TREATMENT PLANT OPERATIONS

A summary of the results from the subject sewage treatment plant operations is presented in Table 50.

One of the sewage treatment plants (Dredge Guthrie) was equipped to retain floating solids in the aeration tank. Others let solids flow over a weir into the settling tank, from which they were eventually discharged without proper treatment. Methods to retain floating material in the aeration tank include baffles or a subsurface discharge that would also reduce turbulence in the settling tank.

The diffusers in the aeration tank should be designed to be removed for inspection and/or replacement without draining the aeration tank. After an aeration tank is drained, the floc and bacterial equilibria is upset, the treatment efficiency is reduced, and the pollutional load discharged is increased until a new equilibria of the system is established.

The overflow from the settling tank should prevent the discharge of floating materials which should be returned to the aeration tank by some skimming device. An open pipe at the liquid surface is not effective.

Table 50. SUMMARY OF SEWAGE TREATMENT PLANT OPERATIONS

Dredge	Influent			Effluent		% Reduction		
	BOD mg/l	TSS mg/l	Flow GPD	BOD mg/l	TSS mg/l	BOD	TSS	Men
McFarland	*1060	1190	1090	63	400	94.1	66.4	66
	690	860	1030	780	700	-11.3	13.6	
Gerig	330	720	1610	37	260	73.6	63.9	67
	*590	520	2140	200	410	66.1	21.2	
Guthrie	130	120	2170	74	140	43.1	-11.7	42
Guthrie - heat accelerated	320	320	2140	97	140	69.7	56.2	41

* Includes galley wastes.

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For disinfection a liquid sodium hypochlorite solution would be preferred over powdered calcium hypochlorite, thus reducing the clogging of chlorine lines by solids. No external air should be applied to the tank for mixing. If HTH (calcium hypochlorite mixture) is used, the liquid should be decanted for use and the solids wasted.

The discharge of grease to the sewage treatment plants should be prohibited. However, a trap should be provided to retain any grease that might enter the system through washing of utensils. Grease can upset the operation of sewage treatment plants and present maintenance problems. The grease should be collected and retained for disposal at a shore installation. Care must be taken in the disposal of entrapped grease because a grease trap or storage container could be an incubator for coliform organisms.

Spare parts to replace or repair defective equipment should be stocked aboard the dredges. Daily inspection of mechanical equipment and periodic maintenance of all equipment would assist in providing continuous operation of the sewage treatment plant.

The sanitary water for flushing toilets was taken from the bay or river and equipment should be provided to remove sand and grit.

FLOW PATTERNS

The meal schedule on the Dredges Gerig and Guthrie was:

Breakfast	0730 - 0830
Dinner	1130 - 1230
Supper	1630 - 1730

The schedule was one-half hour earlier on the Dredge McFarland. The changes of shift for personnel on the three dredges were at 0730, 1530 and 2330 hours.

The data from all three dredges show peak flows of up to five times the daily average between 0700 - 0800 - 1100 - 1200 and 1600 - 1700 hours. There were additional periods of increased usage around 0930 and 2000 hours.

COMPONENT WASTE STREAMS

The galley and laundry wastes contribute the highest concentration of BOD and TSS (Table 51). None of these wastes have pH's that would cause problems in waste treatment.

Table 51. SUMMARY OF COMPONENT STREAMS
(Averages)

Location	BOD mg/l	TSS mg/l	pH
Galley	1620	760	7.6
Dishwasher	18	10	8.9
Laundry	270	240	7.9
Shower	83	51	7.3
Air conditioner condensate	26	72	6.7

CONTROL TESTS

Relative stability, oxygen demand index (ODI), volume of floc, and light penetration determinations were evaluated as treatment plant operating control tests.

Methylene-blue is the indicating dye in the relative stability test. Either chlorine in a sample or an excess of reagents used to dechlorinate a sample seriously affect the test by inhibiting decomposition. Therefore, this test was eliminated because Corps of Engineer personnel would not be trained in dechlorinating and seeding the wastes.

The oxygen demand index test was evaluated as a control test. The test reagents include concentrated sulfuric acid, the careless handling or improper use of which could lead to serious accidents. The test was eliminated because of the hazards involved and because chlorides interfere with the results.

Volume of floc and light penetration tests were developed to aid in the control of treatment plant operations. A decrease in volume of floc indicates toxicity and/or biological die-off in the system with a resultant reduced efficiency of treatment. An increase in floc volume indicates that solids must be wasted to return to an equilibrium state. Settleable material in the effluent indicates inefficient solids removal. The depth of light penetration in the supernatants of the liquid from the aeration tank and the effluent indicate the efficiency of operation. If the depth of light penetration in the supernatant of the contents of the aeration tank decreases from the previous sample, an imbalance in the system is indicated and the system will produce colloidal and suspended matter that cannot be removed by settling. A well operated plant produces a clear effluent with a large light penetration depth. The light penetration measurements on the supernatants of the two samples should be equal.

RECORDS

Accurate records of sewage treatment plant operation are: (1) valuable as a guide to locate and help solve plant operational problems; (2) proof of performance; (3) the basis on which to justify decisions, expenditures, and recommendations; (4) critical documents in the event of any legal action. Two types of records

should be kept: (1) a diary-type log of useful information such as unusual maintenance work, failure of equipment, accidents, bypassing complaints, etc.; and (2) a tabular record showing the observation or results of each laboratory test made and other available measured data.

A record of the chlorine residual and chlorine dose rate in conjunction will indicate the disinfection provided. A record of the volume of floc and light penetration measurements will indicate trends in plant performance, periods of sludge solids wasting, and effectiveness of organic and solids reduction.

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Standard Methods for the Examination of Water and Wastewater. 12th edition, APHA, AWWA, WPCF, New York, 1965.

APPENDIX A

Correspondence

ENGCW-OS

6 November 1967

Mr. John P. Chase
Acting Director, Federal Activities
Federal Water Pollution Control Administration
633 Indiana Avenue
Washington, D. C. 20242

MURDEN

HELLER

GURNEE

Dear Mr. Chase:

The purpose of this letter is to confirm the understanding reached between representatives of the FWPCA and the Corps of Engineers during the meeting of 31 October 1967, held in your offices and attended by the personnel listed in Inclosure 1.

At the above meeting it was agreed that members of your staff, along with Corps of Engineer personnel, would set up and accomplish tests of the sewage treatment equipment and effluent of selected Corps-owned dredges. A tentative location schedule for each of these dredges is shown in Inclosure 2.

In this connection, it is requested that the FWPCA establish a program for testing the treatment efficiency and effluent quality of the sewage treatment facilities installed aboard Corps of Engineers vessels. An Engineer Regulation, based on this program, will then be developed by the Corps for the guidance of all Engineer Districts.

In the event you concur in the establishment of the testing program, it is further requested that you furnish this office the names and point of contact of those FWPCA personnel who will be assigned to this work.

Sincerely yours,

2 Incls
as

MARK S. GURNEE
Chief, Operations Division
Civil Works

cc: NAD
SAD

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration

TO : Chief, Operations Division, Civil Works
Office of the Army Chief of Engineers

DATE: December 4, 1967

FROM : Chief, Technical Projects Branch
Division of Technical Services

SUBJECT: Testing Program for Corps of Engineers

As the result of a discussion with Mr. A. B. Dreher of your staff today, December 4, 1967, it is my understanding that we have been asked to answer the following questions for the Corps.

1. What is the quality of the effluent from sewage treatment plants of the aerobic digestion-disinfection type now operating on representative Corps' vessels?

2. What control tests and routine inspections are recommended to maintain satisfactory operation of this equipment?

Vessels in which tests will be run will be selected jointly by the Corps and ourselves.

Your comments will be appreciated.

Robert W. Haywood, Jr.

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January 16, 1968

Mr. Mark S. Gurnee, Chief
Operations Division, Civil Works
Office of the Army Chief of Engineers
Bldg. T7, Gravelly Point
Washington, D.C. 20315

Dear Mr. Gurnee:

It was my pleasure to talk with Messrs. Murden and Dreher yesterday, January 15, 1968, and to tell them that we hope to get under way, within the next two weeks, with the initial phase of our progress of testing the sewage treatment plants aboard the dredge McFarland in Galveston Bay. We will keep you advised of our progress.

In view of the Corp's desire to keep all sewage treatment plants as compact and light as possible, we believe it is desirable to study the component waste streams which comprise the total influent to the treatment plant. It is possible that one or more may be found to be suitable for discharge directly to the chlorination control tank for disinfection prior to overboard discharge, this making possible a reduction in size of the other parts of the plant. While an investigation in this detail is somewhat more extensive than that originally planned, the results should be mutually useful.

This, therefore, requested that provisions be made, when practical, for metering and sampling of all components of the total waste influent to the sewage plants to be studied. Included should be shower water, galley wastes, laundry wastes, salt water used for flushing and any other liquid wastes discharging to the sewage treatment plant. In addition, we will need provisions for sampling the influent and effluent to the waste treatment plants as discussed with Mr. Brehmeyer during our trip to Galveston.

It is hoped that these modifications in our original plans are acceptable to you.

Sincerely yours,

Robert W. Haywood, Jr.
Chief, Technical Projects Branch
Technical Programs

cc: Mr. Rademacher
Mr. B. Sacks
Mr. Brehmeyer